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TUMOR CELL BINDING MOLECULE WITH PROTEASE INHIBITING REGION

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<b>(21) International Application Number:</b> PCT/GB91/01322 <b>(22) International Filing Date:</b> 2 August 1991 (02.08.91)  <b>(30) Priority data:</b> 9017083.8 3 August 1990 (03.08.90) GB  <b>(71) Applicant (for all designated States except US):</b> DELTA BIOTECHNOLOGY LIMITED [GB/GB]; Castle Court, Castle Boulevard, Nottingham NG7 1FD (GB).  <b>(72) Inventors; and</b> <b>(75) Inventors/Applicants (for US only) :</b> BALLANCE, David, James [GB/GB]; 11 South Road, West Bridgford, Nottingham NG2 7AG (GB). COURTNEY, Michael, George [GB/GB]; 19 Kirk Lane, Ruddington, Nottingham NG11 6NN (GB).		<b>(74) Agent:</b> BASSETT, Richard, S.; Eric Potter & Clarkson, St. Mary's Court, St. Mary's Gate, Nottingham NG1 1LE (GB).  <b>(81) Designated States:</b> AT (European patent), AU, BE (European patent), CA, CH (European patent), DE (European patent), DK (European patent), ES (European patent), FR (European patent), GB (European patent), GR (European patent), IT (European patent), JP, LU (European patent), NL (European patent), SE (European patent), US.  <b>Published</b> <i>With international search report.</i>
<b>(54) Title:</b> TUMOR CELL BINDING MOLECULE WITH PROTEASE INHIBITING REGION  <b>(57) Abstract</b>  A molecule comprising a first region which binds to a tumour (preferably the receptor for uPA) and a second region which inhibits a (preferably tumour-associated) protease, for example uPA. The first and second regions may be respective antibodies or parts thereof specific for appropriate parts of uPAR and uPA. Preferably, the first region is a uPAR-binding part of uPA, e.g. the 12-32 region thereof, and the second region is PAI-2 or a uPA-inhibiting analogue or part thereof, and the first and second regions are combined to form a single polypeptide, expressible from a transformed host.		

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## TUMOR CELL BINDING MOLECULE WITH PROTEASE INHIBITING REGION

The process of activation of the zymogen plasminogen to the broad spectrum serine protease, plasmin, is mediated by specific plasminogen activators: tissue-type plasminogen activator (tPA) and urokinase-type plasminogen activator (uPA). tPA is primarily responsible for the generation of plasmin in fibrinolysis and its activity is stimulated when bound to fibrin. In humans, and many other species, uPA is important in generating proteolytic activity responsible for extracellular matrix and basement membrane degradation associated with tissue remodelling. Such processes are involved in growth and spread of tumour cells, mammary gland involution, ovulation, embryo development, development of the nervous system, in the normal inflammatory response and in a number of inflammatory diseases (Danø et al, 1985). Elevated levels of uPA have been found in malignant tissue and there is believed to be a general correlation between the amount of uPA and the invasiveness of the tumour. Studies of experimental Lewis lung tumours revealed concentration of uPA at the invasive edge of the tumours. In addition, anti-catalytic antibodies to uPA inhibited the establishment of tumour cells after i.v. injection into mice and inhibited metastasis in chick embryos. The proteolytic activity released by uPA is localized by the binding of plasminogen, plasmin and uPA to specific cell surface receptors (Vassalli et al, 1985; Miles and Plow, 1988) and the importance of receptor-bound uPA in tissue invasion has been demonstrated (Ossowski, 1988). The receptor-binding region has been localized to the growth factor domain of the uPA

molecule in the region of amino acids 12-32 of mature uPA since peptides corresponding to this sequence are able to block the uPA receptor interaction by competition (Appella et al, 1987).

The apparent central role of uPA in malignant disease indicates that inhibition of the activity of uPA might modify the course of the disease. Of the natural inhibitors of uPA, only plasminogen activator inhibitor 1 (PAI-1) and plasminogen activator inhibitor 2 (PAI-2) are sufficiently active and specific enough to be considered (Sprengers and Kluft, 1987). Although PAI-1 is a faster inhibitor of uPA than PAI-2 it is also a very effective inhibitor of tPA and administration of this protein would be likely to compromise fibrinolysis. PAI-2, on the other hand, is a slower inhibitor of tPA and is reported to be inactive against the physiologically important fibrin-stimulated tPA. PAI-2 has been shown to inhibit receptor-bound uPA (Kirchheimer and Remold, 1989a; Pöllänen et al, 1990) and uPA-dependent tissue invasion (Kirchheimer and Remold, 1989b) and thus represents a potentially useful anti-tumour or anti-metastatic agent. Natural sources of PAI-2 yield very small quantities of the protein but EP-A-238 275 discloses the production of recombinant PAI-2 in *E. coli*. Our co-pending application GB8918191.1 discloses the advantageous production of recombinant PAI-2 in *Saccharomyces cerevisiae*.

Fusions of PAI-2 and other polypeptides are described in EP-A-238 275 (page 30) but only in the context of obtaining secretion of the PAI-2 from a transformed cell producing it or

in the context of detecting PAI-2 production as a  $\beta$ -galactosidase fusion.

WO 88/08451 discloses uPA-tPA fusions, but the portion of uPA which is used is the B chain and the intention is to retain the activities of both tPA and uPA. As is described below, the uPA-derived portion (if present) of the molecules of the present invention preferably has substantially no uPA-like amidolytic or proteolytic activity.

One aspect of the invention provides a molecule comprising a first region which binds to a tumour cell and a second region which inhibits a first protease.

The specific tumour-binding may be enabled by the existence on the tumour of structures unique to the tumour, for example tumour-specific antigens such as CEA (carcino-embryonic antigen), pan carcinoma antigen, placental alkaline antigen or polymorphic epithelial mucin antigen. Alternatively, the specificity may arise from the existence of a higher level or density on the tumour cell surface of a structure which is found on normal cells; the receptor for uPA (uPAR) is an example of such a structure.

The tumour-binding region is preferably an entity which will bind to the receptor for uPA (uPAR), as is described in more detail below. Alternatively, it may be any other entity which binds preferentially to a tumour cell, for example the epidermal

growth factor receptor present in some breast carcinomas.

The first protease is preferably tumour-associated and is preferably urokinase-type plasminogen activator (uPA) as is described in more detail below. However, it could be any other protease of which high local levels are associated with tumours, or at least tumours of a given kind. Preferably the protease is one that can be activated or converted from a pro-enzyme or zymogen form by uPA or receptor-bound uPA or by plasmin to generate localised proteolytic activity. The inhibitor region in the molecule of the invention may be an inhibitor of plasmin such as the Pittsburgh variant of  $\alpha_1$ -antitrypsin, an  $\alpha_1$ AT variant having lysine at the  $P_1$  position,  $\alpha_2$ -antiplasmin,  $\alpha_2$ -macroglobulin, aprotinin or any other inhibitor with plasmin inhibitory activity, or it may be an inhibitor of a collagenase such as tissue inhibitor of metallo-proteinases (TIMP) or the related TIMP2. Other proteases believed to be involved in tissue remodelling in neoplasia are proteases of the cathepsin and stromelysin families and it may be beneficial to provide an inhibitor of these activities. Another protease (not tumour-associated) is thrombin, a potent activator of platelet aggregation which activates a number of other cell types, including endothelial cells, thus initiating their response to stress. This serine protease is consequently an important regulator of thrombosis and haemostasis in addition to its role in generation of fibrin. The action of thrombin on platelets and endothelial cells is mediated by the thrombin receptor (Vu et al, 1991) and activation of this receptor involves the cleavage of

an extracellular domain of the receptor by thrombin. Thus, the activation of the thrombin receptor and the consequent activation of platelets and other cell types may be inhibited by a thrombin inhibitor such as  $\alpha_1$ -antitrypsin Pittsburgh. An application of the concept of the current invention to this system is to enhance the anti-thrombin-receptor-activating activity of thrombin by directing the  $\alpha_1$ -AT Pittsburgh to the thrombin receptor or an adjacent cell surface molecule. In this instance the receptor-binding moiety of the hybrid may be a receptor-binding peptide or an antibody or antibody fragment directed against the thrombin receptor. In all of these cases an inhibitory portion of the protease inhibitor may be used instead of the whole molecule.

The molecule thus provides for the targeting of the protease inhibiting region to the tumour cell.

The protease the activity of which is inhibited may be free, bound to its receptor, associated with the cell surface via non-specific interactions or bound to adjacent cells or to extracellular matrix.

The first region is preferably a peptide sequence corresponding to a receptor-binding a region of the tumour-associated protease, which may or may not be the same protease as the protease which is inhibited. Thus, the first region may comprise amino acids 1-32 of uPA or a variant or fragment thereof. By "variant" we mean a region with one or more minor alterations to the amino acid sequence thereof which region is



nevertheless recognisably similar to the said 1-32 region and which still binds to the uPA-binding site on the uPAR. Incidentally, although the region is generally "EGF-like", epidermal growth factor (EGF) itself does not bind to the said site. By "fragment" we mean smaller sequences (preferably at least 10, 15, 19 or 20 amino acids long) which still bind to the binding site of the receptor, for example the 20-30 region of uPA. "Variants" of "fragments" may also be used. The receptor-binding region of the protease may, in the molecule of the invention, be accompanied by other parts of the protease or a pro-form of the protease or a mutant thereof. Such parts or mutants should have at least 50% homology, preferably 60%, 70%, 80%, 90% or 95% homology with the protease (or, in the case of parts, with the corresponding region of the protease) in order to be regarded as parts or mutants thereof. They should, however, at least when present in the molecule of the invention, not have any undesirable level of protease-like proteolytic activity, since otherwise the point of the invention would be lost. Preferably, the protease-derived part of the molecule of the invention, at least when present in the said molecule, has substantially no protease-like proteolytic activity. In the case of uPA, it may be possible to achieve this simply by using a pro-uPA mutant in which Lys<sup>158</sup> has been altered, for example to Gln or Gly, to prevent cleavage by plasmin. The 12-19 and 31-32 residue regions adjacent the 20-30 binding region of uPA seem to help the binding region to bind optimally and are preferably present, or functionally equivalent flanking regions are present.

The first region may alternatively be a monoclonal antibody or part thereof or a genetically engineered counterpart thereof which binds to the protease receptor, preferably uPAR. Preferably, it binds to the protease-binding site of the receptor or it binds to an area of the receptor which is sufficiently close to the said binding site for the bulk of the molecule as a whole to block binding of the protease to the receptor. In this way, not only is the protease-inhibiting region targeted to the receptor, but the protease-binding site of the receptor is blocked, which will prevent binding of the protease to that receptor and thus may further help to prevent the protease from acting on its substrate. Monoclonal antibodies to the protease receptor or other target entity may be prepared by immunising an animal with the target entity or an antigenic part thereof and preparing and selecting an appropriate hybridoma in the conventional way (see Monoclonal Hybridoma Antibodies Ed. J.G.R. Hurrell, CRC Press 1982, incorporated herein by reference). Alternatively, a polyclonal collection of antibodies of restricted specificity may be used. Preferably, however, the antibody is a monoclonal antibody, an  $F_{ab}'$ ,  $(F_{ab})_2$ ,  $F_v$ ,  $scF_v$  or dAb fragment or a synthetic molecule including the minimum recognition unit(s) of a target-entity-specific immunoglobulin.

In other embodiments, the first region consists of any peptide which will bind to the protease-binding site, or sufficiently close to it to block it, and need not be homologous with any part of the protease.

The second region may be any compound which inhibits the action of the protease (preferably uPA). Such a compound may be an antibody (or antibody fragment etc, as discussed above) directed against the enzymatically active site of the protease, or against such a part of the protease molecule as to block access of the substrate to the active site or against any other part of the protease such that binding of the antibody to the said part prevents or at least reduces the activity of the protease towards its substrate.

In a particularly preferred embodiment, however, the second region is PAI-2 or part thereof or a mutant PAI-2 or part thereof. Preferably, the mutant or part of PAI-2 retains a useful level of the uPA-inhibiting activity of PAI-2. Fusions of the uPAR-binding domain of uPA and PAI-2 or a part or mutant thereof (hereinafter called "uPA-PAI-2 fusions") may exhibit the following properties:

1. binding unoccupied uPAR (ie uPAR unoccupied by uPA) via the growth factor domain, thereby blocking binding by uPA to uPAR,
2. in solution, inhibiting free or receptor-bound uPA, and
3. when receptor-bound, inhibiting receptor-bound uPA.

The molecule should be stable *in vivo*. By "stable *in vivo*", we mean that the molecule is sufficiently stable when

administered parenterally, preferably intravenously, to allow useful quantities of it to reach a tumour and bind to the receptors on the tumour cells. In practice, a molecule with a half-life in the human circulation of 30 minutes or longer is considered to be stable. Preferably, the half-life is at least 1 hour, 24 hours, 3 days or more.

The molecules of the invention may be dissolved in suitable delivery vehicles and administered to patients to inhibit or prevent the growth or spread of an actual or suspected tumour. The patient is preferably a human but may be another animal, preferably a mammal, such as a pet (dogs, cats, etc) or an economically important animal (sheep, cattle, pigs, fowl, horses, etc). In the case of administration to animals, the tumour-binding domain is modified for optimal binding to the animal receptor and ideally is the sequence of the said domain of the protease of that animal. In addition, the inhibitor moiety may be modified to effect efficient inhibition of the protease of that animal. The molecules are preferably administered parenterally, for example intravenously, intramuscularly or subcutaneously, by injection or infusion. Clinically qualified people will be able to determine suitable dosages, delivery vehicles and administrative routes.

The molecules of the invention may be produced by chemically linking the said first and second regions by methods known to those in the art of protein chemistry, for example using the methods of O'Sullivan et al (1979) and bifunctional linking

reagents such as m-maleimido-benzoyl-N-hydroxy-succinimide ester. However, it is preferred for the molecules to be produced by expression of a recombinant DNA sequence in a suitable host transformed therewith. Such hosts are legion and include *E. coli*, *B. subtilis*, *Aspergillus* and other filamentous fungi, yeasts, animal cells, plant cells, insect cells and transgenic whole animals and plants.

Exemplary genera of yeast contemplated to be useful in the practice of the present invention are *Pichia*, *Saccharomyces*, *Kluyveromyces*, *Candida*, *Torulopsis*, *Hansenula*, *Schizosaccharomyces*, *Citeromyces*, *Pachysolen*, *Debaromyces*, *Metschunikowia*, *Rhodospiridium*, *Leucosporidium*, *Botryosaccharum*, *Sporidiobolus*, *Endomycopsis*, and the like. Preferred genera are those selected from the group consisting of *Pichia*, *Saccharomyces*, *Kluyveromyces*, *Yarrowia* and *Hansenula*, because the ability to manipulate the DNA of these yeasts has, at present, been more highly developed than for the other genera mentioned above.

Examples of *Saccharomyces* are *Saccharomyces cerevisiae*, *Saccharomyces italicus* and *Saccharomyces rouxii*.

Examples of *Kluyveromyces* are *Kluyveromyces fragilis* and *Kluyveromyces lactis*.

Examples of *Hansenula* are *Hansenula polymorpha*, *Hansenula anomala* and *Hansenula capsulata*.

*Yarrowia lipolytica* is an example of a suitable *Yarrowia* species.

Yeast cells can be transformed by: (a) digestion of the cell walls to produce spheroplasts; (b) mixing the spheroplasts with transforming DNA (derived from a variety of sources and containing both native and non-native DNA sequences); and (c) regenerating the transformed cells. The regenerated cells are then screened for the incorporation of the transforming DNA.

It has been demonstrated that yeast cells of the genera *Pichia*, *Saccharomyces*, *Kluyveromyces*, *Yarrowia* and *Hansenula* can be transformed by enzymatic digestion of the cell walls to give spheroplasts; the spheroplasts are then mixed with the transforming DNA and incubated in the presence of calcium ions and polyethylene glycol, then transformed spheroplasts are regenerated in regeneration medium.

Methods for the transformation of *S. cerevisiae* are taught generally in EP 251 744, EP 258 067 and WO 90/01063, all of which are incorporated herein by reference.

In the case of PAI-2-based fusions, the protein is preferably produced as a soluble intracellular protein.

Suitable promoters for *S. cerevisiae* include those associated with the *PGK1* gene, *GAL1* or *GAL10* genes, *CYC1*, *PHO5*, *TRP1*, *ADH1*, *ADH2*, the genes for glyceraldehyde-3-phosphate

dehydrogenase, hexokinase, pyruvate decarboxylase, phosphofructokinase, triose phosphate isomerase, phosphoglucose isomerase, glucokinase,  $\alpha$ -mating factor pheromone,  $\alpha$ -mating factor pheromone, the *PRB1* promoter, the *GUT2* promoter, and hybrid promoters involving hybrids of parts of 5' regulatory regions with parts of 5' regulatory regions of other promoters or with upstream activation sites (eg the promoter of EPA-258067). The preferred promoter is the *PRB1* promoter.

The transcription termination signal is preferably the 3' flanking sequence of a eukaryotic gene which contains proper signals for transcription termination and polyadenylation. Suitable 3' flanking sequences may, for example, be those of the gene naturally linked to the expression control sequence used, ie may correspond to the promoter. Alternatively, they may be different in which case the termination signal of the *S. cerevisiae ADH1* gene is preferred.

Suitable secretion leader sequences, if the molecule is to be secreted from the host, include mammalian leader sequences, such as the HSA and pro-uPA leader sequences, *S. cerevisiae* leader sequences such as the  $\alpha$ -mating factor pheromone pre- and prepro- sequence, the invertase (*SUC2*) leader sequence, the *PHO5* leader sequence, or hybrid leader sequences such as the leader sequence of WO 90/01063.

The amino acid sequence of the N-terminal portion of uPA encompassing the growth factor domain is as follows:

13

10 20 30  
S N E L H Q V P S N C D C L N G G T C V S N K Y F S N I H W C N  
40 50  
C P K K F G G Q H C E I D K S K T C

The sequence of residues 20-30 is believed to be responsible for the specificity of binding to the receptor and this sequence may represent the minimum requirement for binding to the receptor. Sequences adjacent to this region provide the proper conformation for optimum binding but may be substituted by a functionally equivalent structure. The uPA sequence incorporated into the fusion molecules preferably includes residues 12-32 and in the preferred embodiment includes residues 1-47 to ensure optimum binding to uPAR. It is not necessary for the first region of the molecule of the invention to be at or adjacent the N-terminal of the molecule. The second region can be N-terminal to the first region.

DNA sequences for expression of the molecules of the invention may be prepared by known techniques, for example by fusing cDNA fragments prepared from mRNAs corresponding respectively to the receptor-binding region of the protease and to a protease inhibitor or a part thereof.

Monoclonal antibodies may be prepared generally by the techniques of Zola (1988) which is incorporated herein by reference. Useful antigens for preparing either monoclonal or polyclonal antibodies are (for the second region) uPA, low



molecular weight uPA or the heavy (B) chain of uPA, and (for the first region) uPAR or peptides based on the uPA-binding domain thereof. Antibody fragments such as  $F_{ab}$  fragments, may be prepared therefrom in known ways. The antibodies may be humanized in known ways. Antibody-like molecules may be prepared using the recombinant DNA techniques of WO 84/03712.

The art of "antibody engineering" is advancing rapidly, as is described in Tan & Morrison (1988), Williams (1988) and Neuberger et al (1988) (all of which are incorporated herein by reference), and is well suited to preparing the first or second regions of the molecules of the invention or the whole molecule itself. Thus, bispecific antibodies, specific for an appropriate receptor and an appropriate site on the protease, may be made by any of the methods described by Williams (1988). Such molecules will block the protease-binding site of the receptor and also inhibit the protease. The antibody may alternatively be bispecific for the receptor and the protease inhibitor (or a mutant or fragment thereof) so that the antibody acts to bind the inhibitor to the receptor. The combination of the antibody bound to the inhibitor (or a mutant or fragment thereof) thus constitutes a molecule of the invention, whereas the antibody itself constitutes a precursor thereof, forming a separate aspect of the invention. The antibody specific for the receptor and the inhibitor may be combined with the inhibitor before being administered or may be co-administered therewith. By "co-administered", we do not necessarily mean that the antibody and the inhibitor must be administered simultaneously; it is

sufficient for them to combine in a therapeutically useful way in the body.

Chimaeric antibodies, where the  $F_c$  region is a human immunoglobulin or part thereof, may be desirable for long term treatment, to reduce adverse immunological responses. Single chain antibodies may be used for either or both of the two regions of the molecules of the invention.

Preferred embodiments will now be described by way of example and with reference to the accompanying figures.

Figure 1 illustrates the construction of plasmids pDBP1, pDBP2 and pDBP3. E = *EcoRI*, P = *PstI*, Bg = *BglII*, H = *HindIII*, B = *BamHI* and A = *AflIII*. Only the *AflIII* site present in the PAI-2 encoding sequence is shown;

Figure 2 (on four sheets) shows a DNA sequence encoding, and corresponding amino acid sequence of, PAI-2 in pDBP1;

Figure 3 shows the DNA sequence of the *PRB1* promoter;

Figures 4 to 8 respectively illustrate plasmids pAYE333, pAYE334, pAYE335, pDBP5 and pDBP6;

Figure 9 illustrates the construction of plasmids pDJB117 and pDJB118;

Figure 10 illustrates the construction of plasmid pDBUP1;

Figure 11 shows flow cytometer histograms of U937 cells to detect binding of the uPA-PAI-2 hybrid protein to cells. Control cells are shown by the left hand peak and cells incubated with the hybrid protein are shown by the right hand peak. Detection of bound hybrid protein was with anti-PAI-2 antibody and FITC-conjugated secondary antibody;

Figure 12 illustrates the construction of plasmids pDBA2, pDBUA1, pDBUA2 and pDBUA3.

Figure 13 shows the DNA sequences and amino acid sequence encoded thereby, for  $\alpha_1$ antitrypsin in pDBA1.

#### Example 1

Standard recombinant DNA procedures are as described by Sambrook et al, 1989 unless otherwise stated.

#### General

A plasminogen activator inhibitor 2 coding sequence (Figure 1) may be derived from EP-A-238 275. The DNA may be obtained from *E. coli* deposited as ATCC 53585 in connection with EP 238 275. This contains the plasmid pBTA438, comprising the PAI-2 sequence. The sequences encoding the uPA growth factor domain may be assembled from synthetic oligonucleotides by standard

procedures.

However, we obtained a cDNA sequence for PAI-2 ourselves by analogous techniques. An expression vector was constructed in which DNA encoding amino acids 1-47 of uPA, preceded by a methionine initiation codon, directly preceded DNA encoding PAI-2 such that the two coding sequences were in frame. Expression of these sequences was under the control of the *S. cerevisiae* *PRB1* gene promoter and transcription termination was effected by the *S. cerevisiae* *ADH1* terminator.

#### Specific Detail

##### PAI-2 Coding Sequence

A lambda gt11 cDNA library constructed from mRNA isolated from 4-phorbol-12-myristate-13-acetate stimulated cells of the human monocyte-like histiocytic lymphoma cell line U937 (obtained from Clontech Laboratories Inc) was used as a source of PAI-2 cDNA. The library was screened using radioactively labelled oligonucleotide probes corresponding to the DNA sequences encoding the N-terminus (oligo 1) and C-terminal end (amino acids 400-410) (oligo 2) of the PAI-2 protein, respectively by standard procedures.

##### Oligo 1

5'-ATG GAG GAT CTT TGT GTG GCA AAC ACA CTC TTT-3

Oligo 2

5'-GCC GAA AAA TAA AAT GCA CTT GGT TAT CTT ATG-3'

From the putative positive clones we selected one clone (lambda gt11-186) which appeared to contain the entire PAI-2 coding region. This was confirmed by sequence analysis of the DNA insert in this clone following transfer to M13mp19 to form pDBP1 (Figure 1). The sequence is shown in Figure 2.

To facilitate insertion into expression vectors, restriction enzyme recognition sites were created at the 5' and 3' ends of the PAI-2 gene. A *Bgl*III site was created at the 5' end of the gene using the anti-sense oligonucleotide primer 1:

5'-TGCCACACAAAGATCTTCCATTGTTTCAATCT-3'

to create a mutation in the third position of the second codon as shown below:

M E D L C V A

5'...AGATTGAAACA ATG GAG GAT CTT TGT GTG GCA...3'

3'...TCTAACTTTGT TAC CTC CTA GAA ACA CAC CGT...5'

changed to:-

M E D L C V A

5'...AGATTGAAACA ATG GAA GAT CTT TGT GTG GCA...3'

3'...TCTAACTTTGT TAC CTT CTA GAA ACA CAC GCT...5'

┌────────┐

*Bgl*III

An *Afl*III site was created at the 3' end of the gene using

the anti-sense oligonucleotide primer 2:

5'-CAGAAGCAGCACGCTTAGTCTTAAGGTGAGGAAATCTGCC-3'

to create mutations in the third position of the last codon (proline) and in the first base after the stop codon as shown below:-

G R F S S P STOP

5'...GGC AGA TTT TCC TCA CCC TAA AACTAAGCGTGCTGCTTCTG...3'

3'...CCG TCT AAA AGG AGT GGG ATT TTGATTCGCACGACGAAGAC...5'

changed to:

G R F S S P STOP

5'...GGC AGA TTT TCC TCA CCT TAA GACTAAGCGTGCTGCTTCTG...3'

3'...CCG TCT AAA AGG AGT GGA ATT CTGATTCGCACGACGAAGAC...5'

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AflIII

These two oligonucleotides were annealed to single stranded pDBP1 and then used in an *in vitro* mutagenesis procedure (oligonucleotide-directed *in vitro* mutagenesis system-version 2, Amersham plc) carried out according to the manufacturer's recommendations. A clone derived from this procedure and with the correct changes was designated pDBP2 (Figure 1).

Oligonucleotide linkers were then used to position restriction sites at either end of the gene which are suitable for insertion of the gene into an expression vector. The linker positioned at the 5' end of the gene was

Linker 1

5'-AGCTTGTCTGACGGATCCAAAAAG ATG GAA

ACAGCTGCCTAGGTTTTTC TAC CTT CTAG-5'

[ ]

[ ]

[ ]

*HindIII**BamHI**BglII*

and the 3' linker was

Linker 2*HindIII*

[ ]

5'-TTAAGTCGACAAGCTTG

CAGCTGTTCTGAACCTAG-5'

[ ]

[ ]

*AflIII**BamHI*

These two linkers were ligated with the *BglII*-*AflIII* PAI-2 gene fragment from pDBP2 into *HindIII* + *BamHI* digested M13mp19 to form pDBP3 (Fig 1).

PRB1 Promoter

The structural gene, *PRB1*, for the *Saccharomyces cerevisiae* vacuolar endoprotease B has been isolated (Moehle et al, 1987a) on two *prb1* complementing plasmids called MK4 and FP8. When the yeast *Saccharomyces cerevisiae* is grown on glucose in shake flask culture, very little protease B activity is detected until the cells have catabolised the glucose and are utilising the ethanol

accumulated during growth (Saheki and Holzer, 1975; Jones et al, 1986). This is believed to be a consequence of a transcriptional control mechanism which represses mRNA accumulation until the glucose has been exhausted and the culture enters the diauxic plateau (Moehle et al, 1987a). Studies with protease B (*prb1*<sup>-</sup>) deficient mutants implicate protease B in the protein degradation that occurs when negative cells are starved of nitrogen and carbon (Wolf and Ehmann, 1979; Zubenko and Jones, 1981).

The DNA sequence of the *PRB1* gene has been reported, as has 150bp of the *PRB1* promoter (Moehle et al, 1987b). A more extensive DNA sequence of the *PRB1* promoter is also available as an entry in the Genbank database, release 60, accession number M18097, locus YSCPRB1, Figure 3.

The whole of the *PRB1* promoter may be used, or a smaller portion thereof, as may readily be determined. For example, the roughly 1kbp sequence extending upstream from the start codon to the *SnaB1* site is effective.

The 1.435kbp *HindIII*-*EcoRI* DNA fragment containing the protease B promoter (Figure 3) was cloned into the polylinker of the M13 bacteriophage mp18 (Yanisch-Perron et al, 1985), generating plasmid pAYE333 (Figure 4). Double stranded pAYE333 was linearised by partial digestion with *SnaB1* and the double stranded oligonucleotide linker 3 inserted by ligation.



Linker 3

5'-GCGGCCGC-3'

3'-CGCCGGCG-5'

┌────────┐

NotI

This generated a NotI restriction site at the 5' end of the protease B promoter. The promoter element was further modified by site directed mutagenesis (oligonucleotide direct *in vitro* mutagenesis system-Version 2, Amersham) according to the manufacturer's instructions. Mutagenesis with the oligonucleotide

5'-CGCCAATAAAAAACAAGCTTAACCTAATTC-3'

introduced a HindIII restriction site close to the ATG translation initiation codon:

CGCCAATAAAAAACAAGCTTAACCTAATTCCTACAAGCAAAGATG

| |

Met

| |

\* \*

CGCCAATAAAAAACAAGCTTAACCTAATTCCTACAAGCAAAGATG

┌────────┐

Met

HindIII

Plasmid pAAH5 (Goodey et al, 1987) was linearised by partially digesting with BamHI. The 5' protruding ends were

blunt-ended with T4 DNA polymerase and ligated with the double-stranded oligonucleotide Linker 3. A recombinant plasmid pAYE334 (Figure 5) was selected in which a *NotI* restriction site had replaced the *BamHI* site at the 3' end of the *ADH1* terminator.

The 0.8kbp *NotI-HindIII* modified protease B promoter sequence was placed upstream of the 0.45kbp *HindIII-NotI ADH1* transcription terminator on a pAT153-based plasmid (Twigg and Sherratt, 1980) to generate pAYE335 (Figure 6).

The large 6.38kbp *HindIII-BamHI* fragment from the yeast *E. coli* shuttle vector pJDB207 (Beggs, 1981) was treated with the Klenow fragment of *E. coli* DNA polymerase to create flush ends and ligated with the double stranded oligonucleotide Linker 3 to generate plasmid pDBP5 (Figure 7).

The 1.25 kbp *NotI* Protease B promoter/*ADH1* terminator cassette from plasmid pAYE335 (Figure 6) was introduced into the unique *NotI* site of plasmid pDBP5, generating pDBP6 (Figure 8).

#### uPA-PAI-2 fused coding region

Two oligonucleotides were synthesised using an Applied Biosystems Inc 380B oligonucleotide synthesiser and annealed to form a linker (linker 5) to encode the C-terminal portion of the uPA growth factor domain (amino acids 24-47 of mature uPA) and the start of the PAI-2 sequence.

Linker 5

Y F S N I H W C N C P K K F G  
TCGAGTAC TTC TCC AAC ATT CAC TGG TGC AAC TGC CCA AAG AAA TTC GGA  
CATG AAG AGG TTC TAA GTG ACC ACG TTG ACG GGT TTC TTT AAG CCT

\_\_\_\_\_

*ScaI*

G Q H C E I D K S M E  
GGG CAG CAC TGT GAA ATA GAT AAG TCA ATG GAA  
CCC GTC GTG ACA CTT TAT CTA TTC AGT TAC CTT CTA G

\_\_\_\_\_

*BglII*

This linker was ligated with a *BglII-HindIII* fragment of pDBP3, representing the remainder of the PAI-2 sequence, into pUC18 at *SaII-HindIII* to form the plasmid pDJB117 (Figure 9).

A second linker representing the *PRB1* ATG environment, a methionine initiation codon and DNA encoding the N-terminal portion of the uPA growth domain (amino acids 1-23 of mature uPA) was assembled by annealing the four oligonucleotides shown below:-

25

Linker 6

oligo 3

\_\_\_\_\_

M S N E L H Q V

GATCAAGCTTAACCTAATTCTAACAAGCAAAG ATG AGC AAT GAA CTT CAT CAG GTA

TTCGAATTGGATTAAGATTGTTTCGTTTC TAC TCG TTA CTT GAA GTA GTC CAT

\_\_\_\_\_

*HindIII*

oligo 6

oligo 4

\_\_\_\_\_

P S N C D C L N G G T C V S N K

CCA TCG AAC TGT GAC TGT CTA AAT GGA GGA ACA TGT GTG TCC AAC AAG

GGT AGC TTG ACA CTG ACA GAT TTA CCT CCT TGT ACA CAC AGG TTG TTC

\_\_\_\_\_

oligo 5

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The plasmid pDJB117 was partially digested with *ScaI* and linearised DNA was isolated from an agarose gel and then digested with *BamHI*. This DNA was ligated with linker 6 to form pDJB118 (Figure 9).

The *HindIII* fragment from pDJB118 (Figure 9) containing the uPA-PAI-2 coding sequence was then introduced into the expression plasmid pDBP6 to form pDBUP1 (Figure 10). Plasmid pDBUP1 contains a *PRB1* promoter fragment to control transcription of the uPA-PAI-2 sequence and the *ADH1* transcription terminator. It also contains sequences of the bacterial plasmid pAT153 (Twigg and Sherratt, 1980), the *leu2d* gene for selection of transformants and part of the 2 $\mu$ m plasmid to provide replication function in *S. cerevisiae*. The plasmid was introduced into a suitable *S. cerevisiae* strain wherein it effected production of the hybrid protein as a soluble intracellular protein which was recognised by anti-PAI-2 and anti-uPA antibodies in Western blotting experiments.

The protein was purified from cell lysates by copper chelate and anion exchange chromatography and was found to inhibit uPA with similar kinetics to PAI-2 itself, ie second order inhibition rate constant of  $1.8 \times 10^6 \text{ M}^{-1}\text{S}^{-1}$ , determined according to Thorsen et al (1988).

The uPA growth factor domain was shown to be functional by its ability to mediate specific binding to U937 cells. The cells were first treated with 50mM glycine HCl, 0.1M NaCl, pH3.0 for 3 minutes at 4°C to remove endogenous cell-bound uPA. The cell suspension was neutralised by the addition of one-fifth volume of 0.5M Hepes, 0.1M NaCl, pH7.5 and then the cells were washed twice with PBS (Dulbecco's  $\text{Ca}^{2+}$  and  $\text{Mg}^{2+}$  free phosphate buffered saline) containing 0.1% (w/v) bovine serum albumin (PBS + BSA).

Aliquots of cells ( $0.5 \times 10^6$ ) were then incubated with or without approximately  $0.5 \mu\text{g}$  uPA-PAI-2 hybrid protein in PBS + BSA for 90 min on ice and then for a further 60 min with 10% (v/v) pooled normal human serum in Dulbecco's PBS with 20mM glucose, 5mM  $\text{Na}_2\text{EDTA}$ , 0.1% (w/v) BSA, 0.1% (w/v)  $\text{NaN}_3$  (PBS + NHS) to block cell membrane  $\text{F}_c$  receptors. The cells were washed three times with PBS + NHS and then incubated with goat anti-PAI-2 antibody (American Diagnostica Inc) in PBS + NHS for 30 min on ice. The cells were then washed twice with PBS + NHS and then incubated with anti-goat IgG antibody conjugated to fluorescein isothiocyanate in PBS + NHS for 30 min on ice. Finally the cells were washed twice with PBS + NHS and resuspended in  $100 \mu\text{l}$  PBS + NHS. The cells were analysed (10,000 cells per analysis) with an Epics 541 Flow Cytometer using a 488nm laser light source and green light fluorescence detection. Figure 11 is an example of the data obtained from such an experiment and shows an increase in fluorescence bound to the cells incubated with the uPA-PAI-2 hybrid indicating that the protein binds to U937 cells. Additional experiments showed that PAI-2 itself did not bind to cells appreciably and that the binding of uPA-PAI-2 to U937 cells was competed by pro-uPA and could be inhibited by anti-uPA antibody but not by anti-PAI-2 antibody. These data demonstrated that the uPA-PAI-2 hybrid protein was able to bind to cells via the uPA receptor. Both the uPA growth factor domain and the PAI-2 domain of the hybrid protein were thus demonstrated to be functional.

Example 2

A human  $\alpha_1$ -antitrypsin cDNA, identical in sequence to that described in the Genbank database, release 60, accession number X01683 V00496, locus HUMA1ATR was amplified by Polymerase Chain Reaction using a Perkin Elmer Cetus DNA thermal cycler according to the manufacturer's instructions. The DNA sequence of the two primary oligonucleotides were:

5' Oligonucleotide

5'-GAGGATCCCCAGGGAGATGCTGCCCAGAAG-3'

3' Oligonucleotide

5'-GGGGAAGCTTTTATTTTGGGTGGGATTCACCACTTTTCC-3'

Upon amplification both the 5' and 3' termini of the  $\alpha_1$ -antitrypsin sequence became modified as follows:

5' Terminus

original

G GTC CCT GTC TCC CTG GCT GAG GAT CCC CAG GGA GAT GCT GCC CAG  
V P V S L A E D P Q G D A A Q

┌────────┐  
BamHI

AAG

K

modified

GAG GAT CCC CAG GGA GAT GCT GCC CAG AAG

E D P Q G D A A Q K

└───┘

*Bam*HI3' Terminus

original GGA AAA GTG GTG AAT CCC ACC CAA AAA TAA CTGCCTCTCG

G K V V N P T Q K \*

modified GGA AAA GTG GTG AAT CCC ACC CAA AAA TAA AAGCTTCCCC

G K V V N P T Q K \* └───┘

*Hind*III

These modifications remove the 23 amino acid signal sequence and introduce a *Hind*III restriction site at the 3' end of the cDNA.

The 1.22kbp modified cDNA was purified, digested with *Hind*III and *Bam*HI inserted and cloned into the *Hind*III-*Bam*HI sites of M13mp19 (Yanisch-Perron et al (1985) *Gene* 33, 103-119) generating pDBA1 (Figure 12). The integrity of human  $\alpha_1$ -antitrypsin was confirmed by dideoxynucleotide sequencing.



A sequence encoding  $\alpha_1$ -antitrypsin Pittsburgh ( $\alpha_1$ AT-P) (Owen et al, 1983) was created using oligonucleotide-directed mutagenesis of pDBA1 using the oligonucleotide shown below

5'-GAGGCCATACCCAGGTCTATCCCC-3'

This resulted in a change in the codon for methionine 358 such that it coded instead for an arginine ie ATG  $\rightarrow$  AGG. This plasmid is pDBA2 (Fig 12).

Two oligonucleotides were synthesised and then annealed to form a linker (Linker 7) to encode the C-terminal portion of the uPA growth factor domain (amino acids 24-47) and the start of the  $\alpha_1$ AT-P sequence.

#### Linker 7

Y F S N I H W C N C P K K F  
AGTAC TTC TCC AAC ATT CAC TGG TGC AAC TGC CCA AAG AAA TTC  
CATGTCATG AAG AGG TTG TAA GTG ACC ACG TTG ACG GGT TTC TTT AAG

┌────────┐

ScaI

G G Q H C E I D K S E  
GGA GGG CAG CAC TGT GAA ATA GAT AAG TCA GAG  
CCT CCC GTC GTG ACA CTT TAT CTA TTC AGT CTCCTAG

┌────────┐

BamHI

31

This linker was ligated with *KpnI*-*Bam*HI digested double stranded pDBA2 to form pDBUA1 (Fig 12).

A second linker representing the *PRB1* ATG environment, a methionine initiation codon and DNA encoding the N-terminal portion of the uPA growth domain (amino acids 1-23) was assembled by annealing the four oligonucleotides shown below:-

Linker 8

oligo 7

```

|-----|
                                M   S   N   E   L   H   Q   V
AATTAAGCTTAACCTAATTCTAACAAGCAAAG ATG AGC AAT GAA CTT CAT CAG GTA
TTCGAATTGGATTAAGATTGTTTCGTTTC TAC TCG TTA CTT GAA GTA GTC CAT
|-----|

```

*Hind*III

oligo 6

oligo 4

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|-----|
P   S   N   C   D   C   L   N   G   G   T   C   V   S   N   K
CCA TCG AAC TGT GAC TGT CTA AAT GGA GGA ACA TGT GTG TCC AAC AAG
GGT AGC TTG ACA CTG ACA GAT TTA CCT CCT TGT ACA CAC AGG TTG TTC
|-----|

```

oligo 5

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T  
A  
└

Double stranded pDBUA1 was digested with *ScaI* and *EcoRI* and then ligated with linker 8 to form pDBUA2 (Fig 12). The *HindIII* fragment of pDBUA2 was then introduced into the expression plasmid pDBP6 to form pDBUA3 (Fig 12). This plasmid was then introduced into a suitable *S. cerevisiae* strain wherein it effected production of the hybrid protein which was recognised by anti- $\alpha_1$ AT and anti-uPA antibodies in Western blotting experiments.

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CLAIMS

1. A molecule comprising a first region which is capable of binding to a tumour cell and a second region which is capable of inhibiting a first protease.
2. A molecule according to Claim 1 wherein the first region binds to a receptor for a second, tumour-associated protease which may be the same as or different from the first protease.
3. A molecule according to Claim 2 wherein the second tumour-associated protease is uPA.
4. A molecule according to Claim 2 or 3 wherein the first region binds to a receptor in such a way as to block binding thereto by the second protease.
5. A molecule according to Claim 4 wherein the first region comprises a receptor-binding portion of the second protease or a receptor-binding variant of the second protease.
6. A molecule according to any one of the preceding claims wherein the first protease is thrombin.
7. A molecule according to any one of Claims 1 to 5 wherein the first protease is tumour-associated.

8. A molecule according to Claim 7 wherein the first protease is uPA, plasmin, stromelysin or cathepsin.
9. A molecule according to Claim 8 wherein the first region comprises a peptide corresponding to amino acids 20-30 of mature uPA.
10. A molecule according to Claim 9 wherein the first region comprises a peptide corresponding to amino acids 12 to 32 of mature uPA.
11. A molecule according to Claim 10 wherein the first region comprises a peptide corresponding to amino acids 1 to 47 of mature uPA.
12. A molecule according to Claim 10 or 11 wherein the first region comprises a non-plasminogen-activating mutant of uPA or pro-uPA.
13. A molecule according to any one of Claims 9 to 12 wherein the second region is PAI-2 or a uPA-inhibiting variant or fragment thereof.
14. A molecule according to any one of Claims 9 to 12 wherein the second region is  $\alpha_1$ -antitrypsin (Pittsburgh) or a uPA-inhibiting or plasmin-inhibiting variant or fragment thereof.



15. A molecule according to any one of the preceding claims comprising a polypeptide consisting of the first and second regions and, optionally, an intervening amino acid sequence combined to form a single, linear amino acid sequence.
16. A nucleotide sequence encoding a polypeptide as defined in Claim 15.
17. A process of producing a molecule according to any one of Claims 1 to 15 comprising (a) preparing the said first and second regions and joining them together or (b) preparing the first and second regions and, optionally, an intervening amino acid sequence, as a single linear polypeptide by expressing a nucleotide sequence encoding the polypeptide in a suitable host cell transformed with the nucleotide sequence.
18. A process according to Claim 17 (b) wherein the host cell is a *Saccharomyces cerevisiae* cell.
19. A method of combatting neoplasms comprising administering to a patient a molecule according to any one of Claims 1 to 15.
20. A compound which binds specifically to uPAR and to PAI-2.
21. A compound according to Claim 20 wherein the compound is a bispecific antibody.

22. A pharmaceutical composition comprising a molecule according to any one of Claims 1 to 15 or a compound according to Claim 20 or 21.

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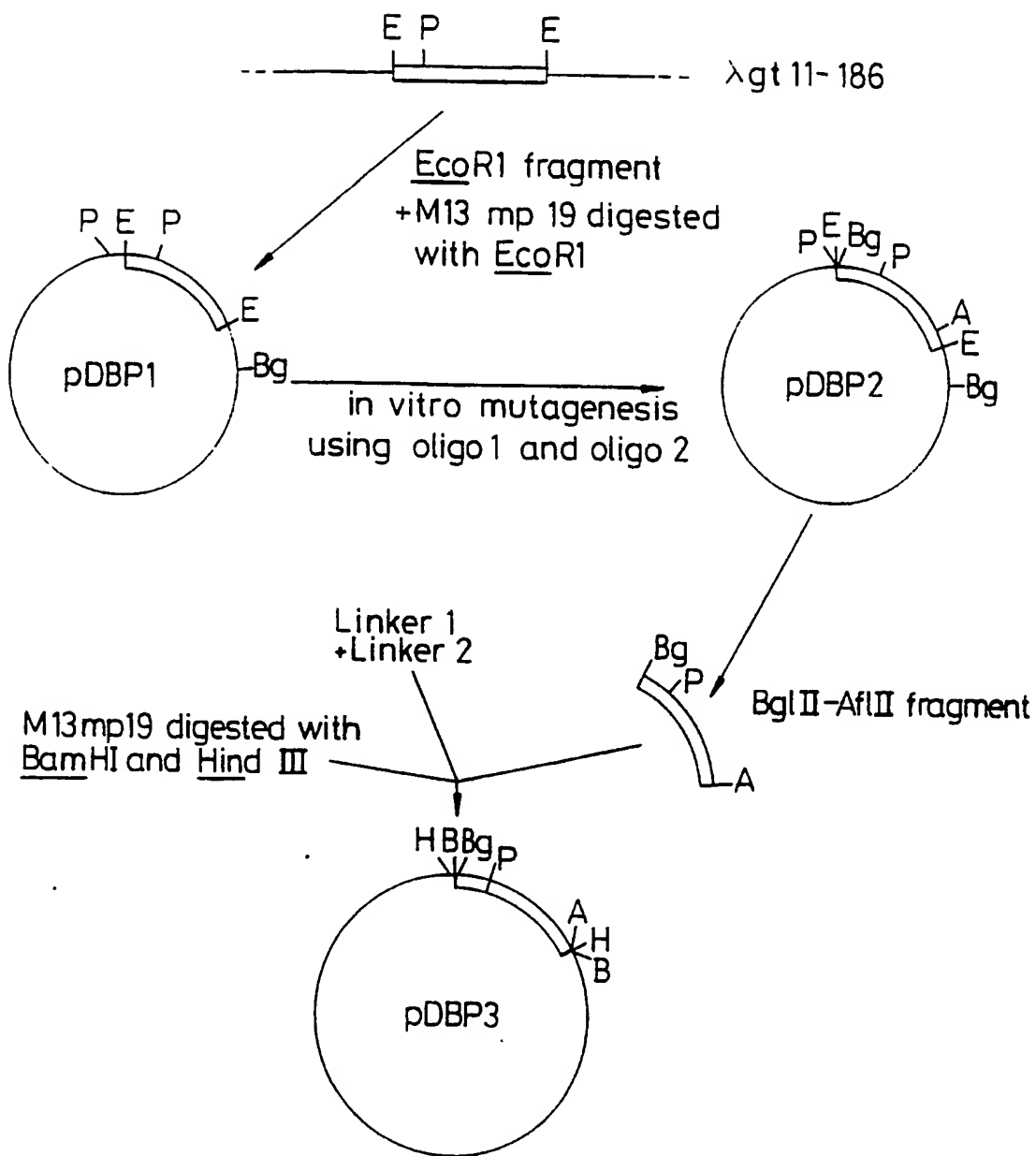


Fig. 1

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AGCAACTCAG AGAATAACCA GAGAACAACC AGATTGAAAC A ATG GAG GAT CTT  
53

Met Glu Asp Leu  
1

TGT GTG GCA AAC ACA CTC TTT GCC CTC AAT TTA TTC AAG CAT CTG GCA  
101  
Cys Val Ala Asn Thr Leu Phe Ala Leu Asn Leu Phe Lys His Leu Ala  
5 10 15 20

AAA GCA AGC CCC ACC CAG AAC CTC TTC CTC TCC CCA TGG AGC ATC TCG  
149  
Lys Ala Ser Pro Thr Gln Asn Leu Phe Leu Ser Pro Trp Ser Ile Ser  
25 30 35

TCC ACC ATG GCC ATG GTC TAC ATG GGC TCC AGG GGC AGC ACC GAA GAC  
197  
Ser Thr Met Ala Met Val Tyr Met Gly Ser Arg Gly Ser Thr Glu Asp  
40 45 50

CAG ATG GCC AAG GTG CTT CAG TTT AAT GAA GTG GGA GCC AAT GCA GTT  
245  
Gln Met Ala Lys Val Leu Gln Phe Asn Glu Val Gly Ala Asn Ala Val  
55 60 65

ACC CCC ATG ACT CCA GAG AAC TTT ACC AGC TGT GGG TTC ATG CAG CAG  
293  
Thr Pro Met Thr Pro Glu Asn Phe Thr Ser Cys Gly Phe Met Gln Gln  
70 75 80

ATC CAG AAG GGT AGT TAT CCT GAT GCG ATT TTG CAG GCA CAA GCT GCA  
341  
Ile Gln Lys Gly Ser Tyr Pro Asp Ala Ile Leu Gln Ala Gln Ala Ala  
85 90 95 100

GAT AAA ATC CAT TCA TCC TTC CGC TCT CTC AGC TCT GCA ATC AAT GCA  
389  
Asp Lys Ile His Ser Ser Phe Arg Ser Leu Ser Ser Ala Ile Asn Ala  
105 110 115

Figure 2 (first sheet)

SUBSTITUTE SHEET

3/16

TCC ACA GGG AAT TAT TTA CTG GAA AGT GTC AAT AAG CTG TTT GGT GAG  
437

Ser Thr Gly Asn Tyr Leu Leu Glu Ser Val Asn Lys Leu Phe Gly Glu

120

125

130

AAG TCT GCG AGC TTC CGG GAA GAA TAT ATT CGA CTC TGT CAG AAA TAT  
485

Lys Ser Ala Ser Phe Arg Glu Glu Tyr Ile Arg Leu Cys Gln Lys Tyr

135

140

145

TAC TCC TCA GAA CCC CAG GCA GTA GAC TTC CTA GAA TGT GCA GAA GAA  
533

Tyr Ser Ser Glu Pro Gln Ala Val Asp Phe Leu Glu Cys Ala Glu Glu

150

155

160

GCT AGA AAA AAG ATT AAT TCC TGG GTC AAG ACT CAA ACC AAA GGC AAA  
581

Ala Arg Lys Lys Ile Asn Ser Trp Val Lys Thr Gln Thr Lys Gly Lys

165

170

175

180

ATC CCA AAC TTG TTA CCT GAA GGT TCT GTA GAT GGG GAT ACC AGG ATG  
629

Ile Pro Asn Leu Leu Pro Glu Gly Ser Val Asp Gly Asp Thr Arg Met

185

190

195

GTC CTG GTG AAT GCT GTC TAC TTC AAA GGA AAG TGG AAA ACT CCA TTT  
677

Val Leu Val Asn Ala Val Tyr Phe Lys Gly Lys Trp Lys Thr Pro Phe

200

205

210

GAG AAG AAA CTA AAT GGG CTT TAT CCT TTC CGT GTA AAC TCG GCT CAG  
725

Glu Lys Lys Leu Asn Gly Leu Tyr Pro Phe Arg Val Asn Ser Ala Gln

215

220

225

CGC ACA CCT GTA CAG ATG ATG TAC TTG CGT GAA AAG CTA AAC ATT GGA  
773

Arg Thr Pro Val Gln Met Met Tyr Leu Arg Glu Lys Leu Asn Ile Gly

230

235

240

Figure 2 (second sheet)

SUBSTITUTE SHEET

4/16

TAC ATA GAA GAC CTA AAG GCT CAG ATT CTA GAA CTC CCA TAT GCT GGA  
 821  
 Tyr Ile Glu Asp Leu Lys Ala Gln Ile Leu Glu Leu Pro Tyr Ala Gly  
 245                      250                      255                      260

GAT GTT AGC ATG TTC TTG TTG CTT CCA GAT GAA ATT GCC GAT GTG TCC  
 869  
 Asp Val Ser Met Phe Leu Leu Leu Pro Asp Glu Ile Ala Asp Val Ser  
 265                      270                      275

ACT GGC TTG GAG CTG CTG GAA AGT GAA ATA ACC TAT GAC AAA CTC AAC  
 917  
 Thr Gly Leu Glu Leu Leu Glu Ser Glu Ile Thr Tyr Asp Lys Leu Asn  
 280                      285                      290

AAG TGG ACC AGC AAA GAC AAA ATG GCT GAA GAT GAA GTT GAG GTA TAC  
 965  
 Lys Trp Thr Ser Lys Asp Lys Met Ala Glu Asp Glu Val Glu Val Tyr  
 295                      300                      305

ATA CCC CAG TTC AAA TTA GAA GAG CAT TAT GAA CTC AGA TCC ATT CTG  
 1013  
 Ile Pro Gln Phe Lys Leu Glu Glu His Tyr Glu Leu Arg Ser Ile Leu  
 310                      315                      320

AGA AGC ATG GGC ATG GAG GAC GCC TTC AAC AAG GGA CGG GCC AAT TTC  
 1061  
 Arg Ser Met Gly Met Glu Asp Ala Phe Asn Lys Gly Arg Ala Asn Phe  
 325                      330                      335                      340

TCA GGG ATG TCG GAG AGG AAT GAC CTG TTT CTT TCT GAA GTG TTC CAC  
 1109  
 Ser Gly Met Ser Glu Arg Asn Asp Leu Phe Leu Ser Glu Val Phe His  
 345                      350                      355

CAA GCC ATG GTG GAT GTG AAT GAG GAG GGC ACT GAA GCA GCC GCT GGC  
 1157  
 Gln Ala Met Val Asp Val Asn Glu Glu Gly Thr Glu Ala Ala Ala Gly  
 360                      365                      370

Figure 2 (third sheet)

**SUBSTITUTE SHEET**

5/16

ACA GGA GGT GTT ATG ACA GGG AGA ACT GGA CAT GGA GGC CCA CAG TTT  
1205

Thr Gly Gly Val Met Thr Gly Arg Thr Gly His Gly Gly Pro Gln Phe

375

380

385

GTG GCA GAT CAT CCT TTT CTT TTT CTT ATT ATG CAT AAG ATA ACC AAC  
1253

Val Ala Asp His Pro Phe Leu Phe Leu Ile Met His Lys Ile Thr Asn

390

395

400

TGC ATT TTA TTT TTC GGC AGA TTT TCC TCA CCC TAAACTAAG CGTGCTGCTT  
1306

Cys Ile Leu Phe Phe Gly Arg Phe Ser Ser Pro

405

410

415

CTGCAAAAGA TTTTGTAGA TGAGCTGTGT GCCTCAGAAT TGCTATTTCA AATTGCCAAA  
1366

AATTTAGAGA TGTTTTCTAC ATATTTCTGC TCTTCTGAAC AACTTC  
1412

Figure 2 (fourth sheet)

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*HindIII*

aagcttactgctgacctttgccttggtccttgtacttgtctcgattgctgnnaccattaa  
cggttttttgttcttactttaatctttttttcccgacgacgcaaaatgtcagaaaagata  
taaanagagcaacgtttcctgctacatgaaacacgctggcatatagaagaacttcaacga  
gcgaggctctctgaacaatctgctaactcgtagcaagtaagggttctcgtgacagtcaccg  
tgtataaacaagnnnaaacagataaacagtcagatatgcttaatttttaactgtaggctg  
tgccgacatgccattttatgcggtcacttctaacaaaagtgaccatgacgcacaagcaa  
gcaaacagccaagtaaggaagcagacagcttcacagcacacacacaccgttggtgtacgaa

*SnaBI*

aatcctctgcagaagagtgtatatgccactcatccacacttccgcagcgcagtagcgtaat  
gcggtatcgtgaaagcgaaaaaaaactaacagtagataagacagatagacagatagaga  
tgagcagagaaacagggggggagaaaaggggaaaagagaaggaaagaaagactcatctatc  
gcagataagacaatcaaccctcatggcgccctccaaccaccatccgcactagggaccaagc  
gctcgcaccgttagcaacgcttgactcacaacccaactgccggtgaaagagcttggtgca  
atgggagtgccaattcaaaggagccgaatacgtctgctcgcccttttaagaggctttttga  
acactgcattgcacccgacaaatcagccactaactacgaggtcacggacacatataccaag  
tagttaaaaattacatatatactctatatagcacagtagtgatgataaataaaaaattttgcc  
aagacttttttaactgcacccgacagatcaggtctgtgcctactatgcacttatgcccg  
gggtcccgggaggagaaaaaacgagggctgggaaatgtccgtggactttaaacgctccgg  
gttagcagagtagcagggctttcggttttggaatttaggtgacttggtgaaaagcaaaa  
atgtgggctcagtaatgccactgcagtggcttatcacgccaggactgcgggagtgggggg  
ggcaaacacacccgcgataaagagcgcgatgaatataaaagggggccaatgttacgtccc  
gttatattggagttcttcccatataaaacttaagagtccaattagcttcatcgccaataaa  
aaaacaaactaaacctaattctaacaagcaaagatgaagttagaaaatactctatttaca  
ctcgggtgccctagggagcatctctgctgctttgggtcatcccaaactcttgaatgcccgc

*EcoRI*

gaccaccacgaactgattaacaaggaagatcaccacgagagacccagaaaaagtgggaattc

Figure 3



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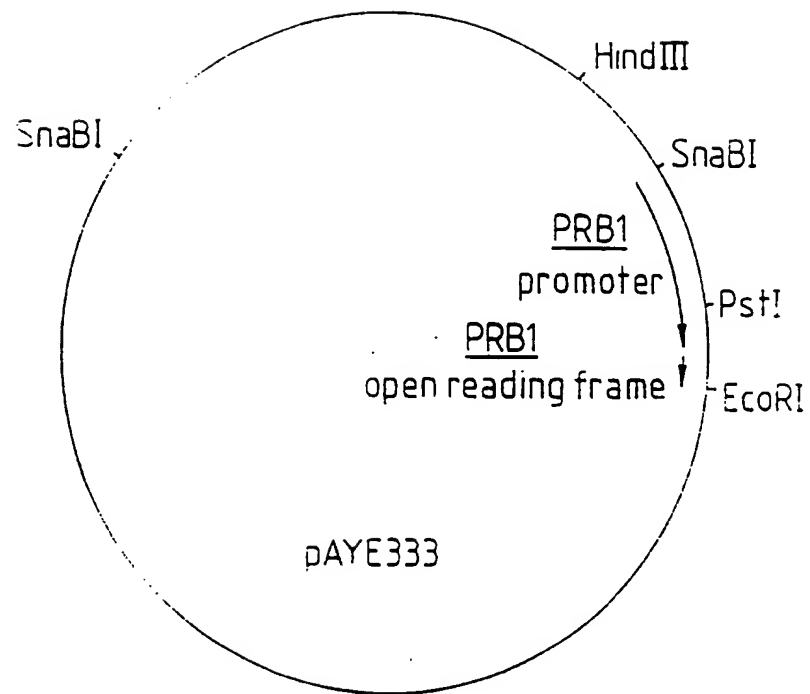


FIGURE 4

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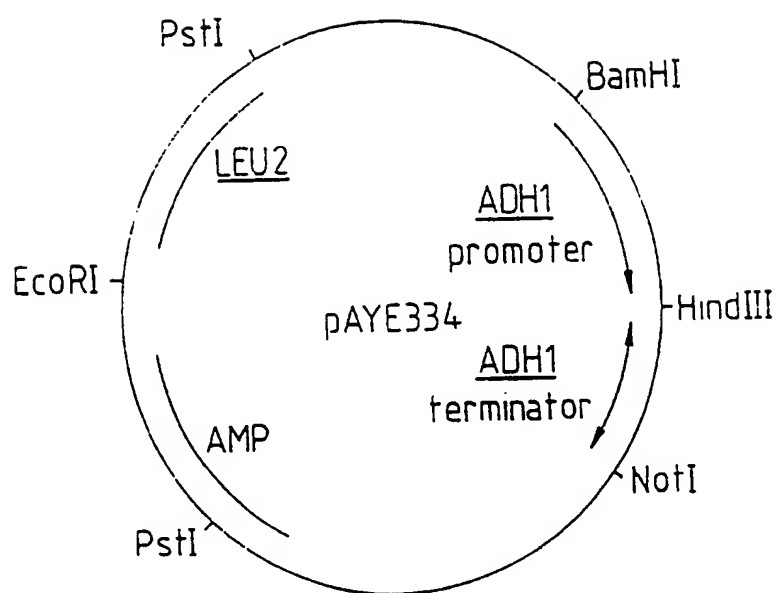


FIGURE 5

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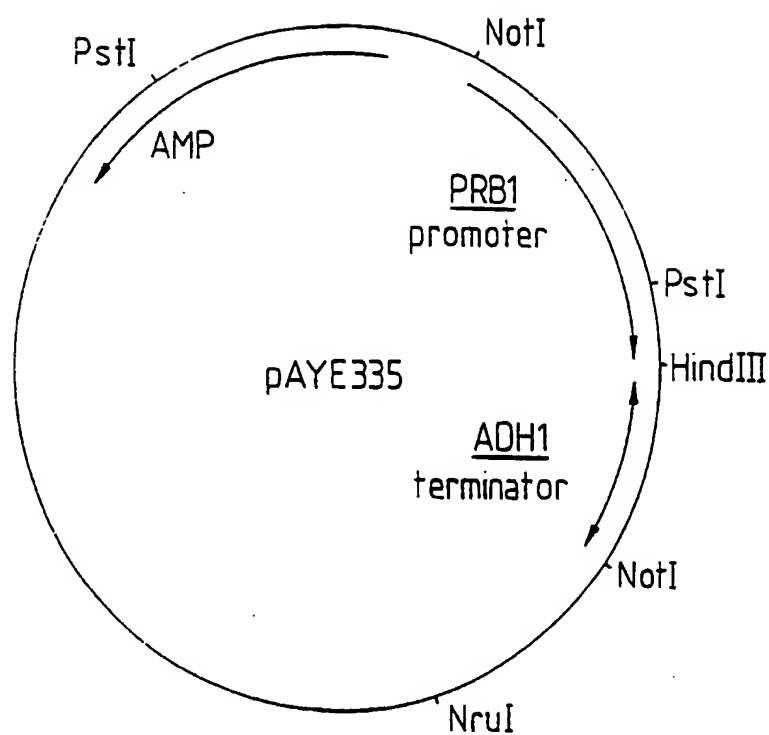


FIGURE 6

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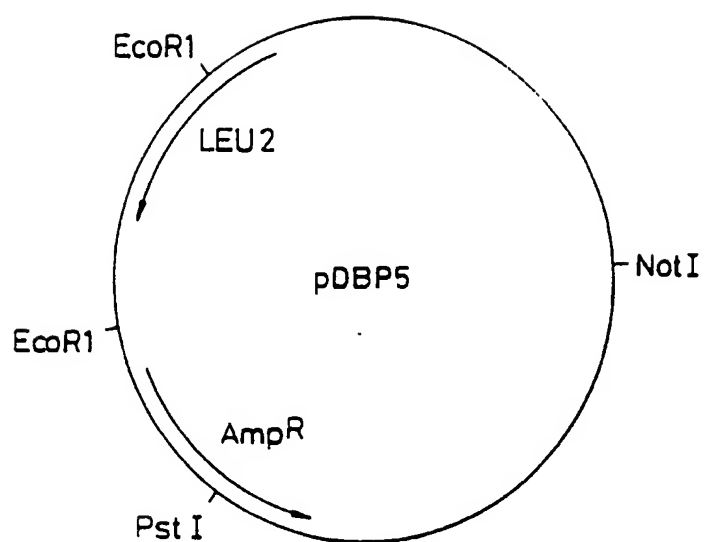


FIGURE 7

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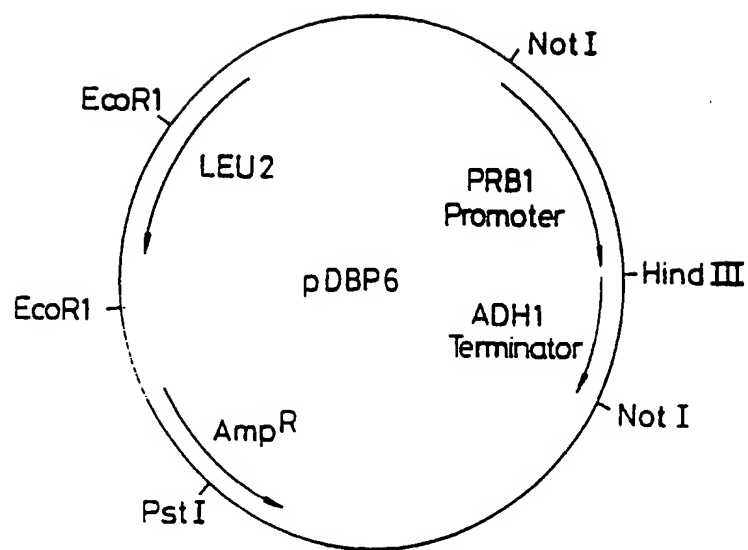


FIGURE 8

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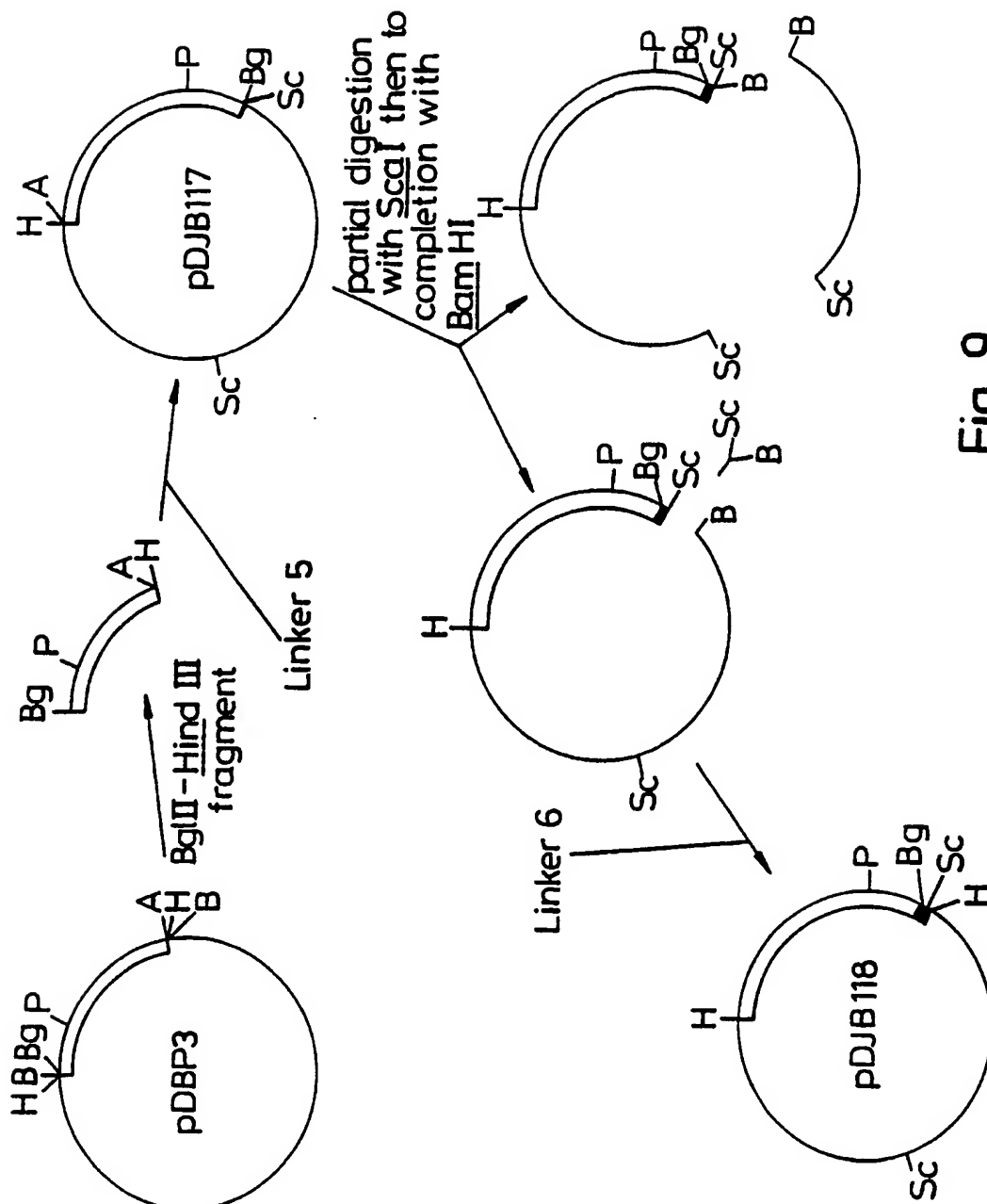


Fig. 9

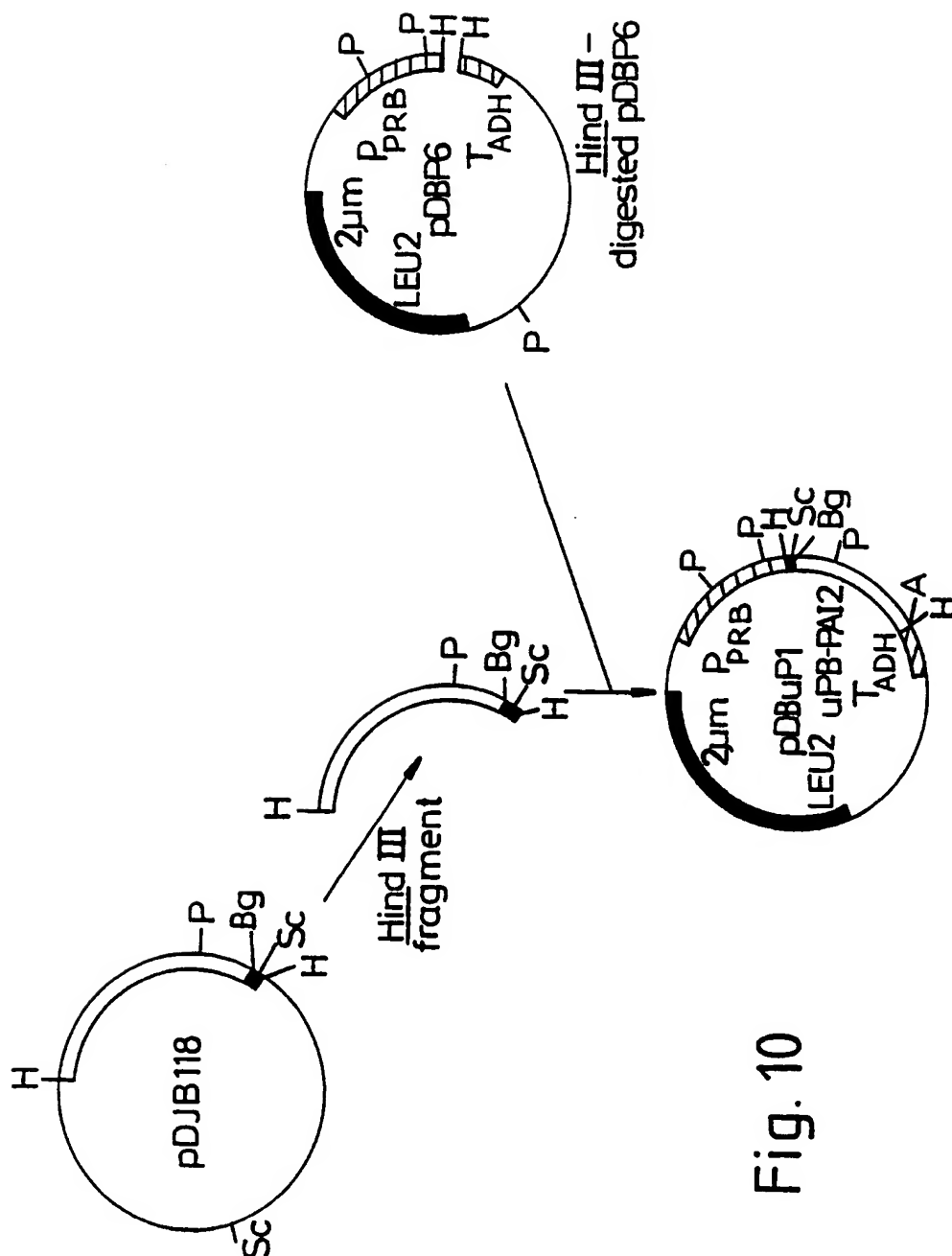


Fig. 10

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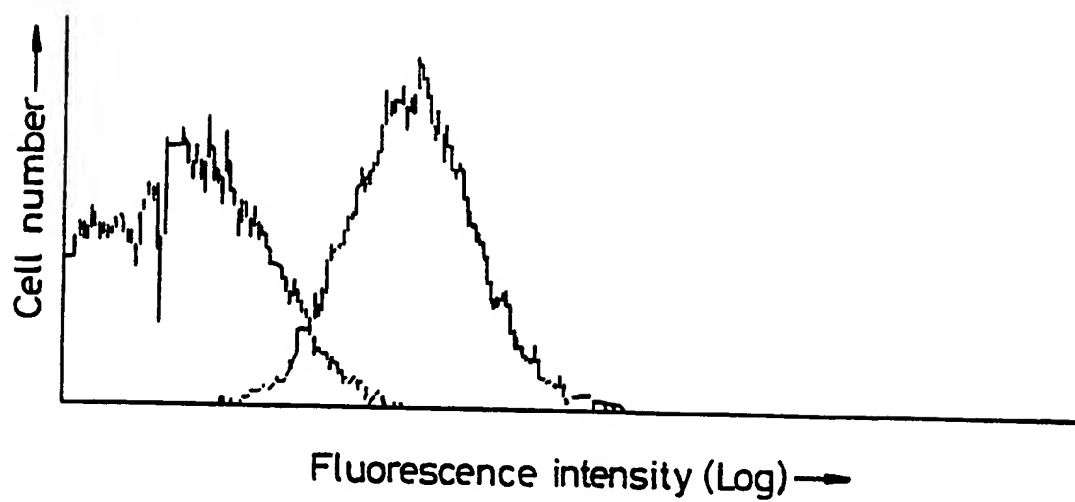


Fig. 11



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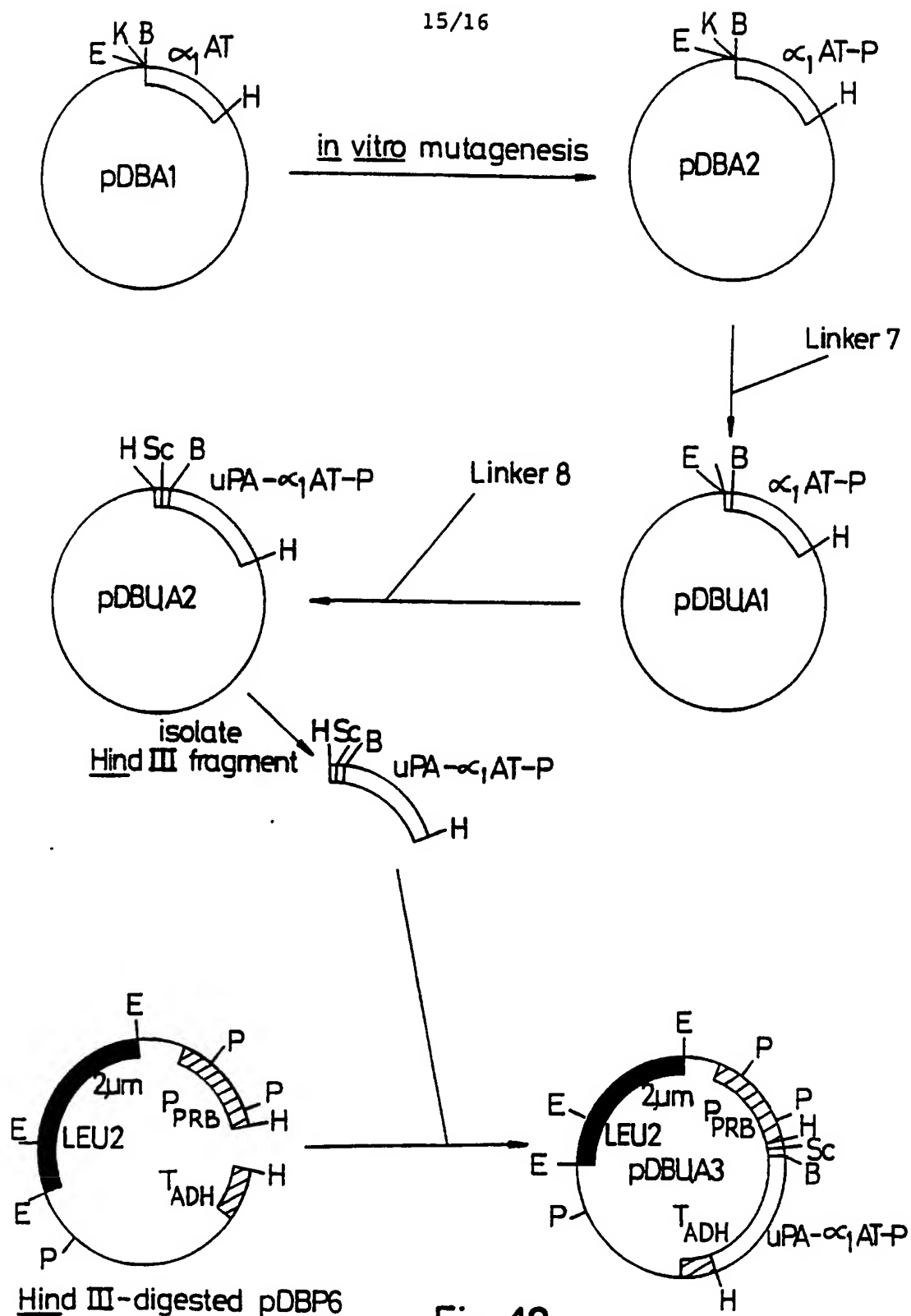


Fig. 12

Alpha-1-antitrypsin

DNA sequence in pDBUA1.

Asp	Pro	Gln	Gly	Asp	Ala	Ala	Gln	Lys	Thr	Asp	Thr	Ser	His	His	Asp	Gln	Asp	His
GAT	CCC	CAG	GGA	GAT	GCT	GCC	CAG	AAG	ACA	GAT	ACA	TCC	CAC	CAC	GAT	CAG	GAT	CAC
Pro	Thr	Phe	Asn	Lys	Ile	Thr	Pro	Asn	Leu	Ala	Glu	Phe	Ala	Phe	Ser	Leu	Tyr	Arg
CCA	ACC	TTC	AAG	ATC	ACC	ACC	ACC	ACC	CTG	GCT	GAG	TTC	TTC	TTC	Val	CTA	TAC	Ala
Gln	CTG	GCA	CAC	TCC	Asn	Asn	Ser	ACC	Asn	Ile	Phe	TTC	Ser	Ser	GTG	Ser	CTA	Ala
CAG	Ala	TTT	Ala	Met	CTC	Leu	CTG	Gly	Thr	Lys	Ala	Asp	Thr	Thr	ATC	AGC	ATC	GCT
ACA	GCC	Phe	GCA	ATG	CTC	Leu	CTG	GGG	ACC	Pro	GCT	GCT	ACT	ACT	GAA	AGC	GAA	Leu
Glu	Gly	Leu	Asn	Phe	Asn	Leu	ACG	Glu	Ile	Pro	Glu	Ala	Gln	Ile	GAA	Glu	ATC	CTG
GAG	GGC	CTG	AAT	TTC	ACC	CTC	CTC	CTC	CTC	CTC	GAG	GCT	CAG	CTC	GAA	Gly	Gly	Phe
Gln	GAA	Leu	CTC	CTC	Thr	CTC	CTC	Gln	Thr	Asp	Ser	AGC	CTC	CTC	CTG	CTG	GTC	TTC
Asn	Gly	Leu	Phe	CTC	CTC	Glu	GAG	CTC	CTC	Asp	Val	Asp	CTC	CTC	CTG	CTC	CTC	Gly
Lys	Lys	CTG	Tyr	CTC	Ser	Glu	GAG	Leu	Val	Leu	Val	Phe	Lys	Phe	Leu	CTG	CTC	Gly
AAA	AAG	TGG	Ile	CTC	CTC	Glu	GCC	CTC	CTC	CTC	CTG	CTC	Gly	CTC	CTG	CTC	CTC	Val
Lys	Lys	Gln	CTG	Asn	CTC	CTC	Val	CTC	CTC	CTC	CTG	CTC	Gly	CTC	CTG	CTC	CTC	Ala
AAG	AAA	CAG	ATC	Asp	Arg	GAA	CTC	CTC	CTC	CTC	CTG	CTC	CTC	CTC	CTG	CTC	CTC	CTC
Val	Lys	Glu	Leu	Asp	Arg	TAC	Val	GAG	CTC	CTC	CTG	CTC	Gly	CTC	CTG	CTC	CTC	CTC
GTC	Lys	GAG	CTT	GAG	Pro	Asp	CTC	GTT	Phe	GCT	CTG	CTC	CTC	CTC	CTG	CTC	CTC	CTC
Gly	Lys	TGG	Glu	Arg	CTC	Phe	GAA	Val	CTC	CTC	CTG	CTC	Glu	Glu	CTG	CTC	CTC	CTC
GGC	AAA	Val	CTG	CTC	CTC	CTC	Val	GTC	Lys	CTC	CTG	CTC	CTC	CTC	CTG	CTC	CTC	CTC
Asp	Gln	Val	CTG	CTC	CTC	CTC	Val	CTC	CTC	CTC	CTG	CTC	CTC	CTC	CTG	CTC	CTC	CTC
GAC	His	Cys	Thr	ACC	CTC	CTC	CTC	CTC	CTC	CTC	CTG	CTC	CTC	CTC	CTG	CTC	CTC	CTC
CAG	His	CTG	Lys	ACC	CTC	Ser	CTC	CTC	CTC	CTC	CTG	CTC	CTC	CTC	CTG	CTC	CTC	CTC
Thr	ACC	Ile	Phe	CTC	CTC	CTC	CTC	CTC	CTC	CTC	CTG	CTC	CTC	CTC	CTG	CTC	CTC	CTC
ACC	GCC	Ala	ATC	CTC	CTC	CTC	CTC	CTC	CTC	CTC	CTG	CTC	CTC	CTC	CTG	CTC	CTC	CTC
Thr	His	Ala	CTC	Ile	CTC	CTC	CTC	CTC	CTC	CTC	CTG	CTC	CTC	CTC	CTG	CTC	CTC	CTC
ACC	CAC	CTG	Leu	CTC	CTC	CTC	CTC	CTC	CTC	CTC	CTG	CTC	CTC	CTC	CTG	CTC	CTC	CTC
His	CTA	Pro	AAA	CTC	CTC	CTC	CTC	CTC	CTC	CTC	CTG	CTC	CTC	CTC	CTG	CTC	CTC	CTC
Leu	Gly	Ile	CTC	CTG	CTC	CTC	CTC	CTC	CTC	CTC	CTG	CTC	CTC	CTC	CTG	CTC	CTC	CTC
CTG	Pro	CTG	Leu	CTC	CTC	CTC	CTC	CTC	CTC	CTC	CTG	CTC	CTC	CTC	CTG	CTC	CTC	CTC
Ala	CCC	CTG	Lys	ACT	CTC	CTC	CTC	CTC	CTC	CTC	CTG	CTC	CTC	CTC	CTG	CTC	CTC	CTC
GCA	Thr	Glu	Ala	GCT	CTC	CTC	CTC	CTC	CTC	CTC	CTG	CTC	CTC	CTC	CTG	CTC	CTC	CTC
Gly	GGG	Val	GCT	Phe	CTC	CTC	CTC	CTC	CTC	CTC	CTG	CTC	CTC	CTC	CTG	CTC	CTC	CTC
GGG	ACT	Val	GTC	CTC	CTC	CTC	CTC	CTC	CTC	CTC	CTG	CTC	CTC	CTC	CTG	CTC	CTC	CTC
Glu	GAG	GTC	Phe	CTC	CTC	CTC	CTC	CTC	CTC	CTC	CTG	CTC	CTC	CTC	CTG	CTC	CTC	CTC
Pro	CCC	Leu	Met	CTC	CTC	CTC	CTC	CTC	CTC	CTC	CTG	CTC	CTC	CTC	CTG	CTC	CTC	CTC
CCC																		

FIGURE 13

# INTERNATIONAL SEARCH REPORT

International Application No PCT/GB 91/01322

<b>I. CLASSIFICATION OF SUBJECT MATTER</b> (If several classification symbols apply, indicate all) <sup>6</sup> According to International Patent Classification (IPC) or to both National Classification and IPC IPC5: C 07 K 15/00, A 61 K 39/395, 47/48, C 12 N 15/62 C 12 P 21/02, 08														
<b>II. FIELDS SEARCHED</b> <div style="text-align: center; border-top: 1px solid black; border-bottom: 1px solid black;">Minimum Documentation Searched<sup>7</sup></div> <table style="width: 100%; border-collapse: collapse;"> <tr> <th style="width: 25%; border-bottom: 1px solid black;">Classification System</th> <th style="border-bottom: 1px solid black;">Classification Symbols</th> </tr> <tr> <td style="height: 40px; vertical-align: top; border-right: 1px solid black;">IPC5</td> <td>A 61 K; C 07 K; C 12 N</td> </tr> </table> <div style="text-align: center; border-top: 1px solid black; border-bottom: 1px solid black;">Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in Fields Searched<sup>8</sup></div>			Classification System	Classification Symbols	IPC5	A 61 K; C 07 K; C 12 N								
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IPC5	A 61 K; C 07 K; C 12 N													
<b>III. DOCUMENTS CONSIDERED TO BE RELEVANT<sup>9</sup></b> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 10%;">Category<sup>*</sup></th> <th style="width: 60%;">Citation of Document<sup>11</sup> with Indication, where appropriate, of the relevant passages<sup>12</sup></th> <th style="width: 30%;">Relevant to Claim No.<sup>13</sup></th> </tr> </thead> <tbody> <tr> <td style="vertical-align: top;">P, X</td> <td>WO, A1, 9012091 (CANCERFORSKNINGSFONDET AF) 18 October 1990, see pages 1-26, 40, 70, in particular page 24, lines 3-5, examples 8-9 and fig 29-30 as well as claims 52-58, 62, 73-77 <div style="text-align: center;">--</div></td> <td style="vertical-align: top;">1-4, 7, 8, 15-17</td> </tr> <tr> <td style="vertical-align: top;">X</td> <td>J. NATL. CANCER INST., vol. 74, No. 5, 1985, Jung-Yaw Lin et al: "Antitumor Lectin-Trypsin Inhibitor Conjugate ", see page 1031 - page 1035 especially "Discussion". <div style="text-align: center;">--</div></td> <td style="vertical-align: top;">1, 6-8</td> </tr> <tr> <td style="vertical-align: top;">X</td> <td>THE FASEB JOURNAL, vol. 4, No. 7, 1990, A.J. Wolfson et al: "Insertion of a protease-binding loop into interleukin-1B ", page A1762 <div style="text-align: center;">--</div></td> <td style="vertical-align: top;">1, 6-8</td> </tr> </tbody> </table>			Category <sup>*</sup>	Citation of Document <sup>11</sup> with Indication, where appropriate, of the relevant passages <sup>12</sup>	Relevant to Claim No. <sup>13</sup>	P, X	WO, A1, 9012091 (CANCERFORSKNINGSFONDET AF) 18 October 1990, see pages 1-26, 40, 70, in particular page 24, lines 3-5, examples 8-9 and fig 29-30 as well as claims 52-58, 62, 73-77 <div style="text-align: center;">--</div>	1-4, 7, 8, 15-17	X	J. NATL. CANCER INST., vol. 74, No. 5, 1985, Jung-Yaw Lin et al: "Antitumor Lectin-Trypsin Inhibitor Conjugate ", see page 1031 - page 1035 especially "Discussion". <div style="text-align: center;">--</div>	1, 6-8	X	THE FASEB JOURNAL, vol. 4, No. 7, 1990, A.J. Wolfson et al: "Insertion of a protease-binding loop into interleukin-1B ", page A1762 <div style="text-align: center;">--</div>	1, 6-8
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<div style="display: flex; justify-content: space-between;"> <div style="width: 45%;"> <p><sup>*</sup> Special categories of cited documents: <sup>10</sup></p> <p><sup>"A"</sup> document defining the general state of the art which is not considered to be of particular relevance</p> <p><sup>"E"</sup> earlier document but published on or after the international filing date</p> <p><sup>"L"</sup> document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p><sup>"O"</sup> document referring to an oral disclosure, use, exhibition or other means</p> <p><sup>"P"</sup> document published prior to the international filing date but later than the priority date claimed</p> </div> <div style="width: 45%;"> <p><sup>"T"</sup> later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p><sup>"X"</sup> document of particular relevance, the claimed invention cannot be considered novel or cannot be considered to involve an inventive step</p> <p><sup>"Y"</sup> document of particular relevance, the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.</p> <p><sup>"&amp;"</sup> document member of the same patent family</p> </div> </div>														
<b>IV. CERTIFICATION</b> <table style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 50%; border-bottom: 1px solid black; vertical-align: top;">           Date of the Actual Completion of the International Search   <b>8th November 1991</b> </td> <td style="width: 50%; border-bottom: 1px solid black; vertical-align: top;">           Date of Mailing of this International Search Report   <b>21. 11. 91</b> </td> </tr> <tr> <td style="border-bottom: 1px solid black; vertical-align: top;">           International Searching Authority   <b>EUROPEAN PATENT OFFICE</b> </td> <td style="border-bottom: 1px solid black; vertical-align: top;">           Signature of Authorized Officer    <b>Miss T. MORTENSEN</b> </td> </tr> </table>			Date of the Actual Completion of the International Search  <b>8th November 1991</b>	Date of Mailing of this International Search Report  <b>21. 11. 91</b>	International Searching Authority  <b>EUROPEAN PATENT OFFICE</b>	Signature of Authorized Officer  <b>Miss T. MORTENSEN</b>								
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III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)		
Category *	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No
X	BIOCHEMISTRY INTERNATIONAL, vol. 19, No. 2, 1989, Jung-Yaw Lin et al: "CHIMERIC PROTEIN: ABRIN B CHAIN-TRYPSIN INHIBITOR CONJUGATE AS A NEW ANTITUMOR AGENT ", see page 313 - page 323 see in particular "Discussion"	1,6-8
Y	--	2,3,15- 17,20, 21
O,Y	THROMBOSIS RESEARCH Supplement XI, 1990, M T Masucci: "The receptor for human urokinase: a potential target for anti-invasive and anti-metastatic therapy ", International symposium on biochemical and pharmacological aspects of thrombotic processes (Brescia ITA), see page 49 - page 60	2,3,15- 17,20- 21
A	Chemical Abstracts, volume 88, no. 23, 5 June 1978, (Columbus, Ohio, US), Verloes, Rene et al: "Tumor growth inhibition mediated by trypsin inhibitor or urokinase inhibitors.", see page 39, abstract 163955w, & Eur.J.Cancer 1978, 14( 1), 23- 31	1
A	EP, A1, 0301122 (MAEDA, HIROSHI) 1 February 1989, see the whole document	1,6,7
A	THE JOURNAL OF BIOLOGICAL CHEMISTRY, vol. 263, No. 5, 1988, Lars S. Nielsen et al: "A55,000-60,000 M Receptor Protein for Urokinase-type Plasminogen Activator ", see page 2358 - page 2363 especially page 2358, right column and page 2363	1-5

**III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)**

Category	Citation of Document, with Indication, where appropriate, of the relevant passages	Relevant to Claim No
X,P	WO, A1, 9100912 (MASSACHUSETTS INSTITUTE OF TECHNOLOGY) 24 January 1991, see page 15 - page 20  --  -----	1,15- 17

ANNEX TO THE INTERNATIONAL SEARCH REPORT  
ON INTERNATIONAL PATENT APPLICATION NO.PCT/GB 91/01322

SA 50125

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO-A1- 9012091	18/10/90	AU-D- 5528090	05/11/90
EP-A1- 0301122	01/02/89	JP-A- 62294622	22/12/87
WO-A1- 9100912	24/01/91	NONE	

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